FUNDAMENTALS OF PHYSICS

Second Edition

Halliday Resnick

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29 Electromotive Force and Circuits

29–1 Electromotive Force

There exist in nature certain devices such as batteries and electric generators that are able to maintain a potential difference between two points to which they are attached. We call such devices seats of *electromotive force* (symbol $\mathcal{E}$; abbr. emf). In this chapter we do not discuss their internal construction or detailed mode of action but confine ourselves to describing their gross electrical characteristics and to exploring their usefulness in electric circuits.

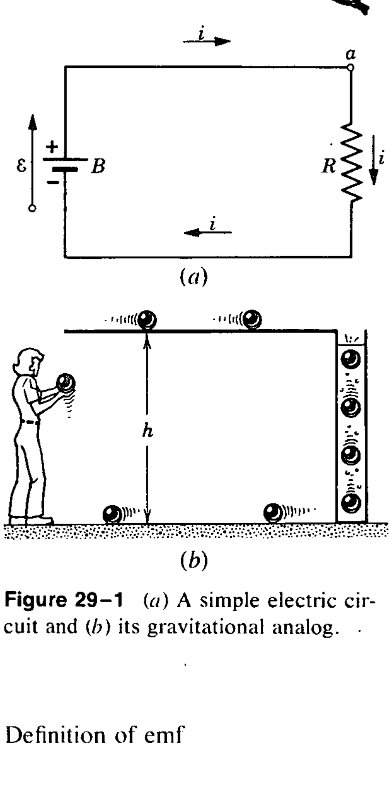

Figure 29–1 (*a*) A simple electric circuit and (*b*) its gravitational analog.

Figure 29–1*a* shows a seat of emf $\mathcal{E}$, represented by a battery, connected to a resistor R. The seat of emf maintains its upper terminal positive and its lower terminal negative, as shown by the + and − signs. In the circuit external to $\mathcal{E}$ positive charge carriers would be driven in the direction shown by the arrows marked i. In other words, a clockwise current would be set up.

An emf is represented by an arrow that is placed next to the seat and points in the direction in which the seat, acting alone, would cause a positive charge carrier to move in the external circuit. We draw a small circle on the tail of an emf arrow so that we will not confuse it with a current arrow.

A seat of emf must be able to do work on charge carriers that enter it. In the circuit of Fig. 29–1*a*, for example, the seat acts to move positive charges from a point of low potential (the negative terminal) through the seat to a point of high potential (the positive terminal). This reminds us of a pump, which can cause water to move from a place of low gravitational potential to a place of high potential.

Definition of emf

In Fig. 29–1*a* a charge dq passes through any cross section of the circuit in time dt. In particular, this charge enters the seat of emf $\mathcal{E}$ at its low-potential end and leaves at its high-potential end. The seat must do an amount of work dW on the (positive) charge carriers to force them to go to the point of higher potential. The emf $\mathcal{E}$ of the seat is defined from

$$\mathcal{E} = dW/dq. \tag{29-1}$$